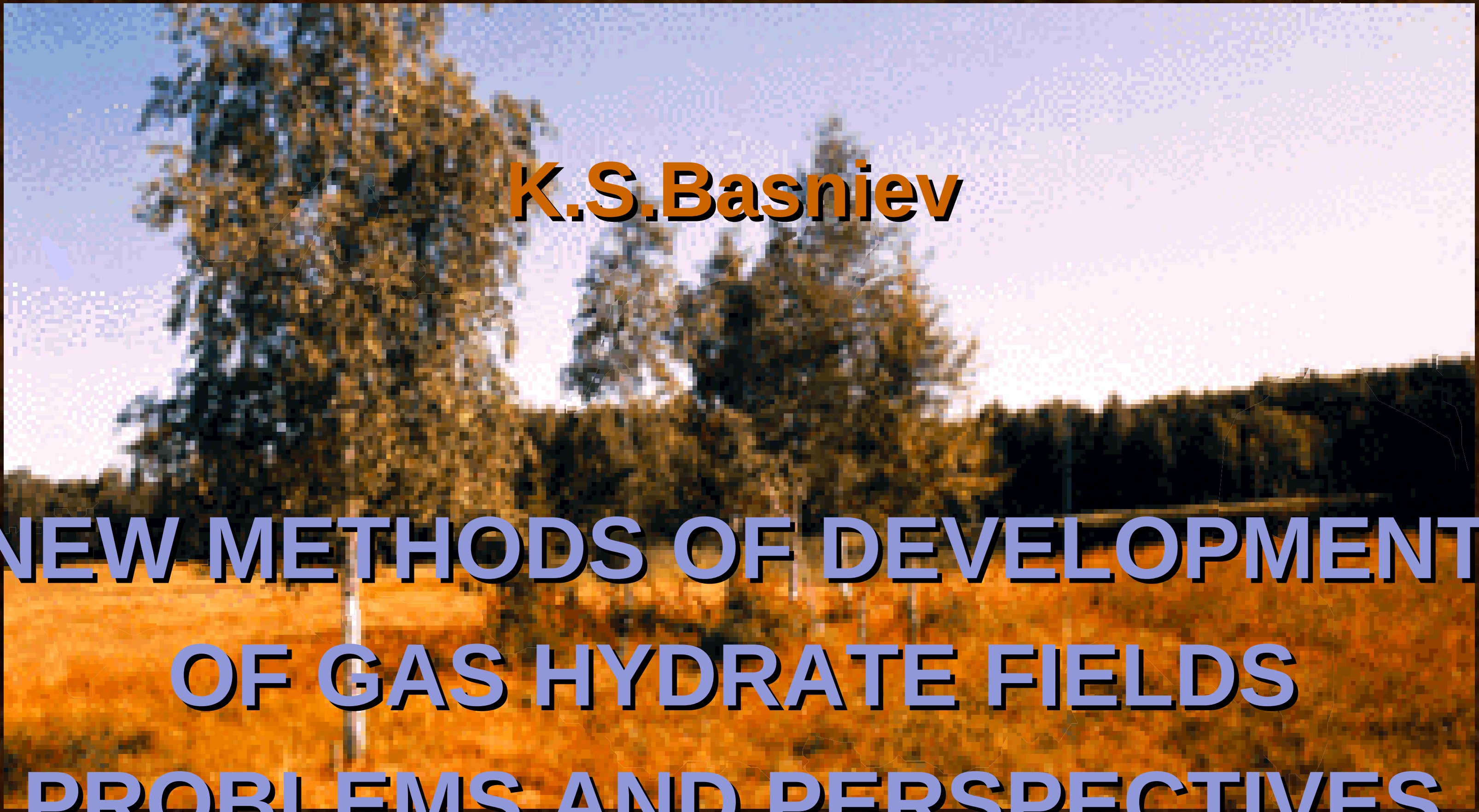
K.S.Basniev



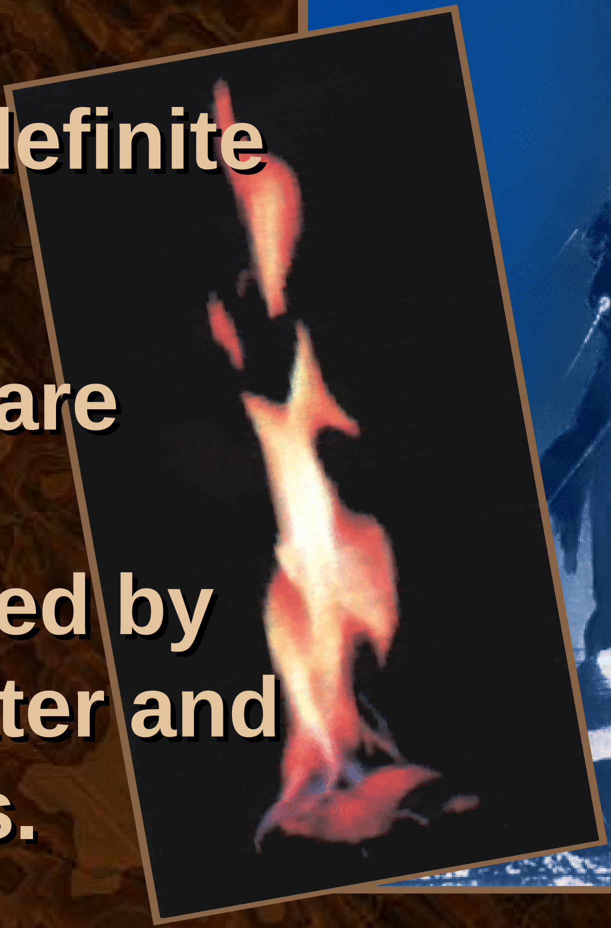
NEW METHODS OF DEVELOPMENT OF GAS HYDRATE FIELDS PROBLEMS AND PERSPECTIVES

Gubkin Russian State University of Oil and Gas, Moscow, Russia

K.S.Basniev ksb@gubkin.ru

Gas hydrates are crystalline compounds (clatrates) of definite structure.

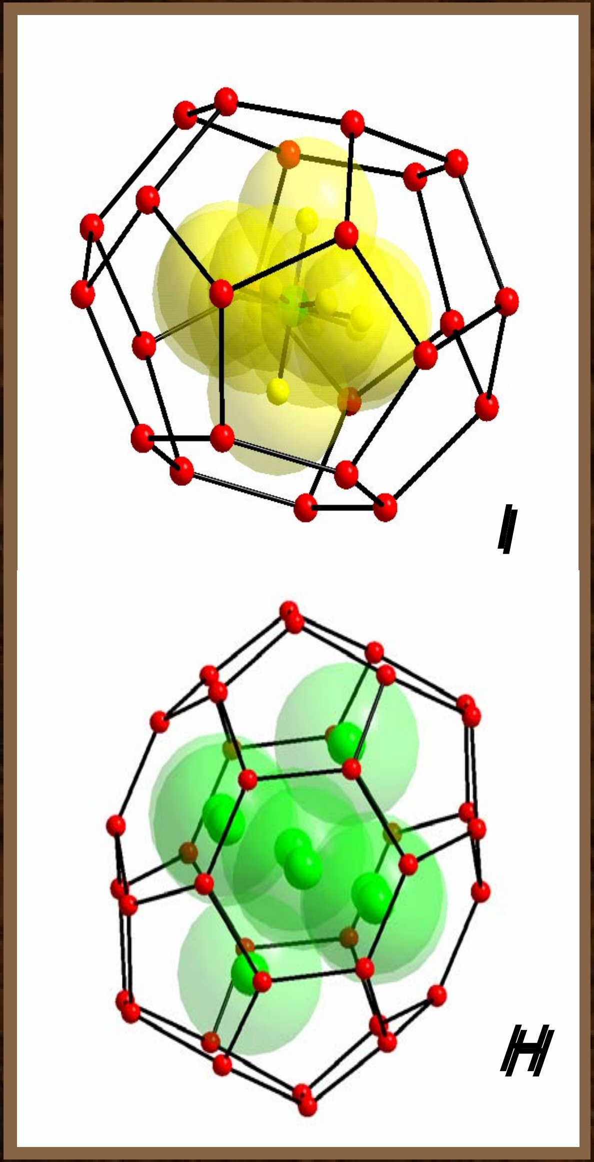
Gas hydrates are methastable minerals formed by combining water and gas molecules.



Gubkin Russian State University of Oil and Gas, Moscow, Russia

K.S.Basniev ksb@gubkin.ru, k_basniev@mail.ru

Components of natural gas (CH_4, C_2H_6, C_3H_8, i-C_4H_{10}, CO_2, N_2, H_2S) form both individual and mixed hydrates.



Gubkin Russian State University of Oil and Gas, Moscow, Russia
K.S.Basniev ksb@gubkin.ru, k_basniev@mail.ru

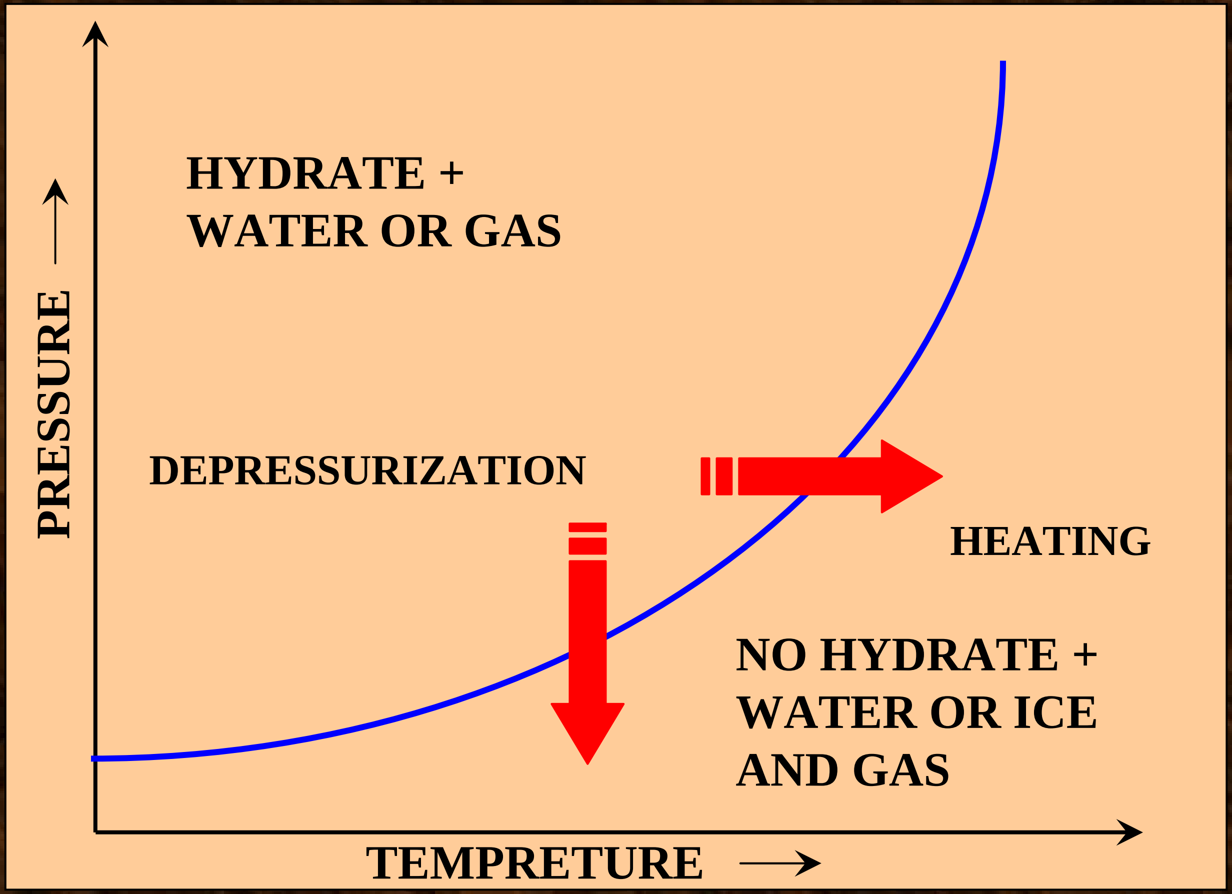
The possibility of existence of gas hydrate reservoirs in nature conditions was shown in experiments, made in Russia and registered as a scientific discovery in **1969** by **Iu.F.Makogon, F.A.Trebin, V.G.Vasiliev, N.V.Chersky, A.A.Trofimuk**.

K.S.Basniev ksb@gubkin.ru, k_basniev@mail.ru

Worldwide gas reserves in hydrate state exceed 16·10^{12} T.O.E. About 98% are concentrated offshore. Only 2% (300 trln.m^3) of the reserves are onshore.

K.S.Basniev ksb@gubkin.ru, k_basniev@mail.ru

Hydrate equilibrium curve



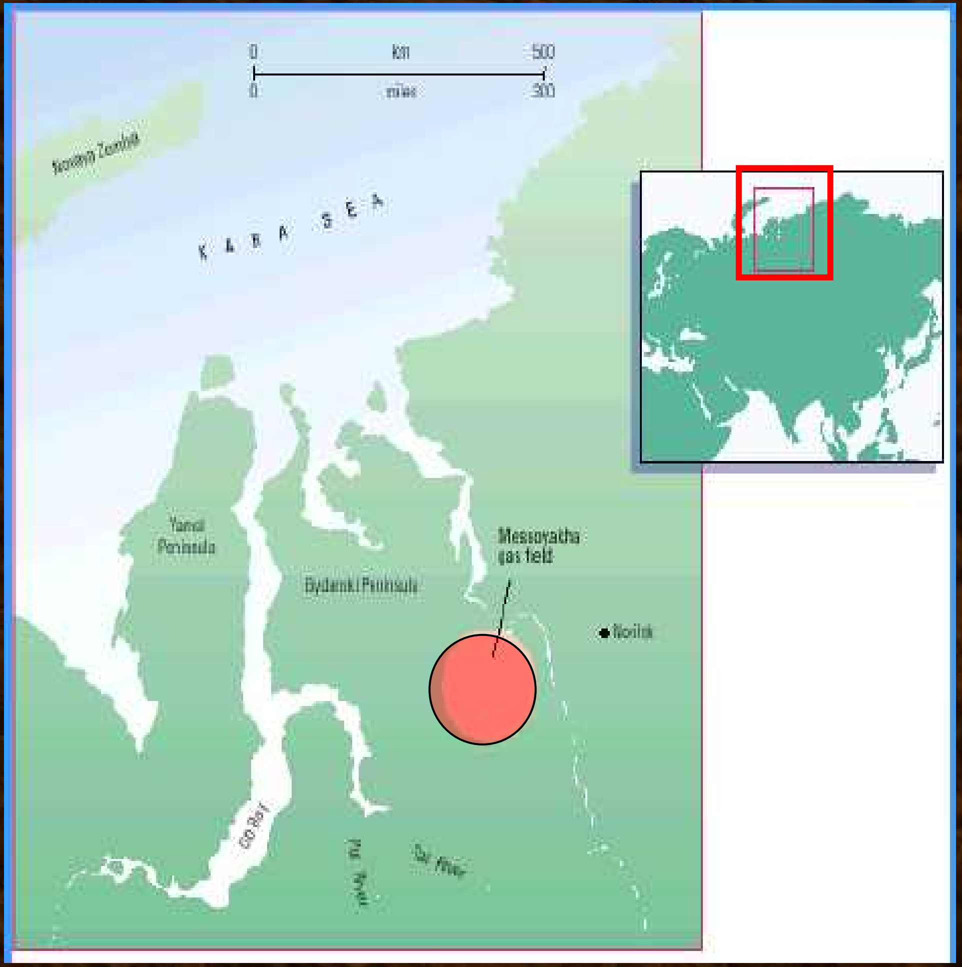
K.S.Basniev ksb@gubkin.ru, k_basniev@mail.ru

In 1970 the existence of gas hydrate fields and the possibility of their industrial development was confirmed by beginning of development of the first Messoyakha field.

K.S.Basniev ksb@gubkin.ru, k_basniev@mail.ru

Messoyakha field (1970 г.)

- The depth of deposit is about **850 m**.
- The depth of permafrost rocks within the deposit comprises **420-480 m**.
- The initial reservoir pressure is **7.8 MPa**.
- Estimated hydrate saturation ranges from 20 to 40 %.



K.S.Basniev ksb@gubkin.ru, k_basniev@mail.ru

Messoyakha gas-and-gas hydrate field

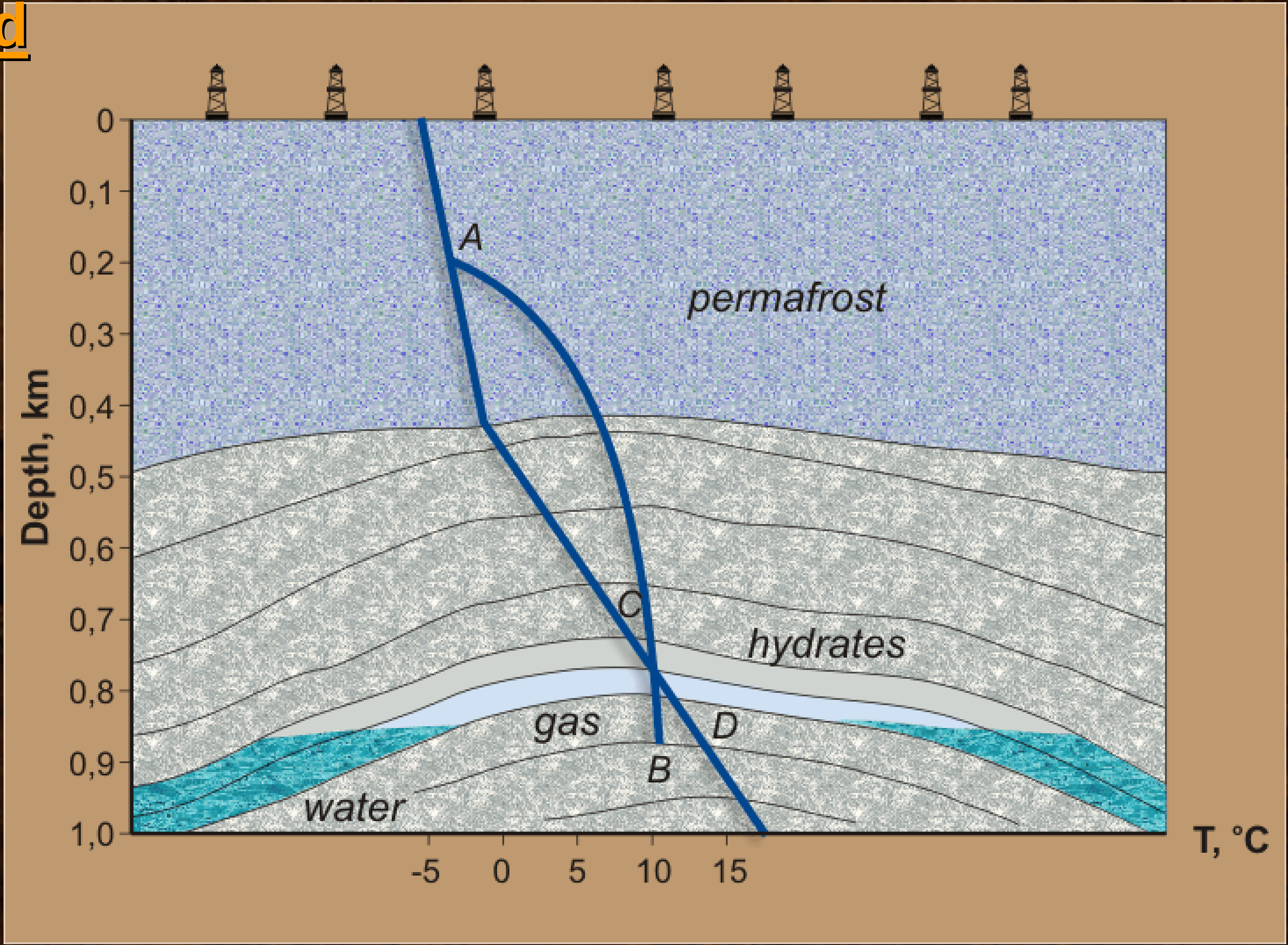
The temperature at the cap of the deposit in its dome part is 8°C and at the bottom - 12°C.

Geothermal gradient in the range of permafrost rocks is 1°C per 100 m,
in underfrost layer of rocks is 3.4°C per 100 m.

Equilibrium temperature is about 10°C.

K.S.Basniev ksb@gubkin.ru, k_basniev@mail.ru

Messoyakha gas-and-gas hydrate field



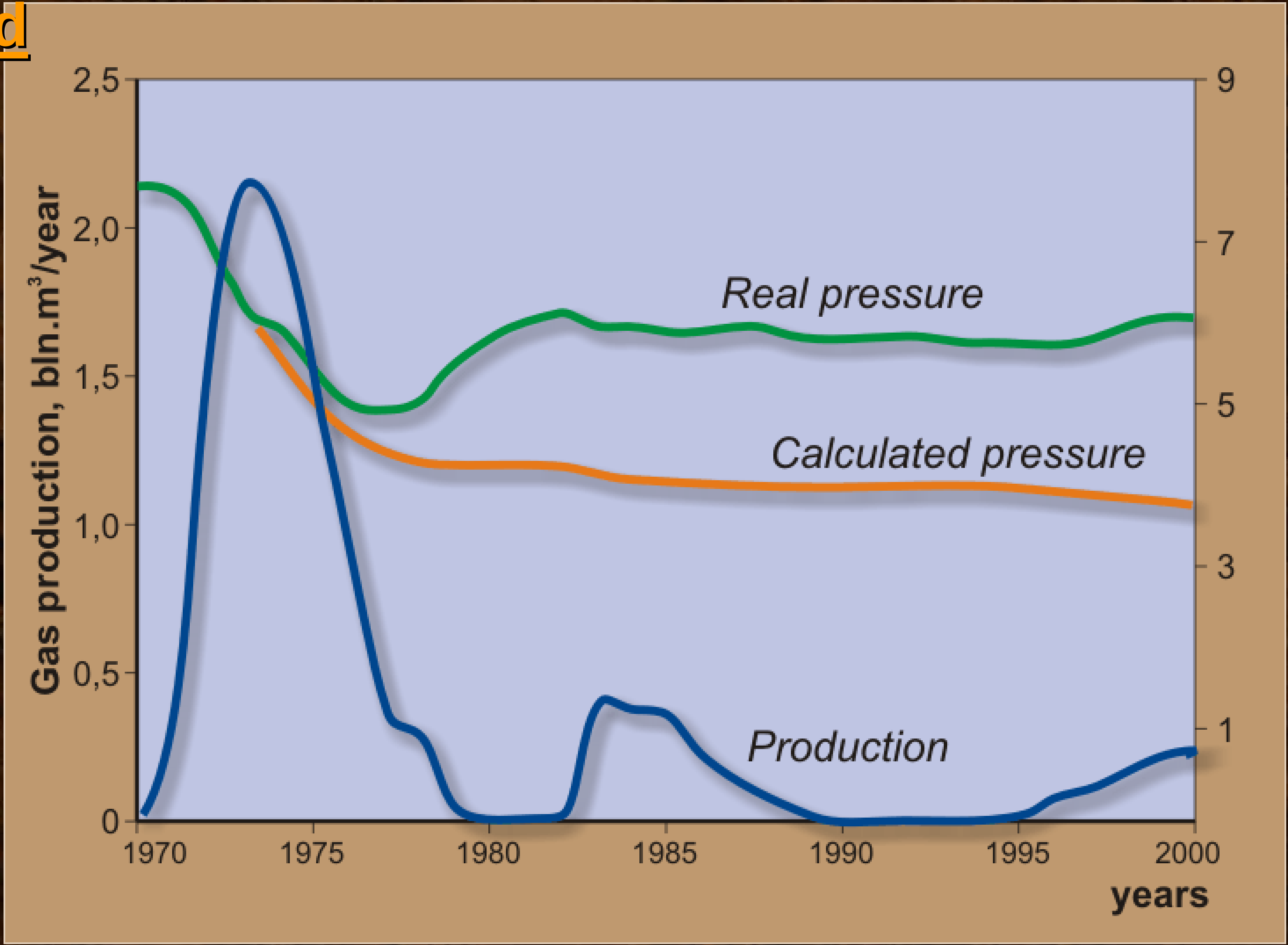
K.S.Basniev ksb@gubkin.ru, k_basniev@mail.ru

Messoyakha gas-and-gas hydrate field

Hydrate saturation of the porous space is from 20 to 40%. On the 1st of January 2001 the accumulated rate production of gas from the deposit accounted for 11.6 bln.m^3 out of which 5.7 bln.m^3 were produced as the result of hydrate decomposition under conditions when reservoir pressure decreased below the equilibrium reservoir pressure.

K.S.Basniev ksb@gubkin.ru, k_basniev@mail.ru

Messoyakha gas-and-gas hydrate field



K.S.Basniev ksb@gubkin.ru, k_basniev@mail.ru

Messoyakha gas-and-gas hydrate field

During 30 years the reservoir pressure decreased from 7.8 to 6.2 MPa.

In the absence of hydrate the reservoir pressure was to be decreased up to 4 MPa.

K.S.Basniev ksb@gubkin.ru, k_basniev@mail.ru

Mallik field (North-western territories, Canada)

Methane reserves trapped in hydrates is about **189 billion m³**(Collett 1999)

Hydrate stability line at the depth of **1100 m**

Permafrost thickness **640 m**

K.S.Basniev ksb@gubkin.ru, k_basniev@mail.ru

Mallik field (North-Western Territories, Canada)

Hydrate saturation is about 80%

Porosity ranges from 20 to 40%

Thickness of hydrate saturated formation 110 m

K.S.Basniev ksb@gubkin.ru, k_basniev@mail.ru

Nankai Trough (offshore Japan)

Total offshore hydrate reserves exceed 4.0-7.0 trillion m3

Hydrate saturation up to 80%

Porosity about 20-30%

K.S.Basniev ksb@gubkin.ru, k_basniev@mail.ru

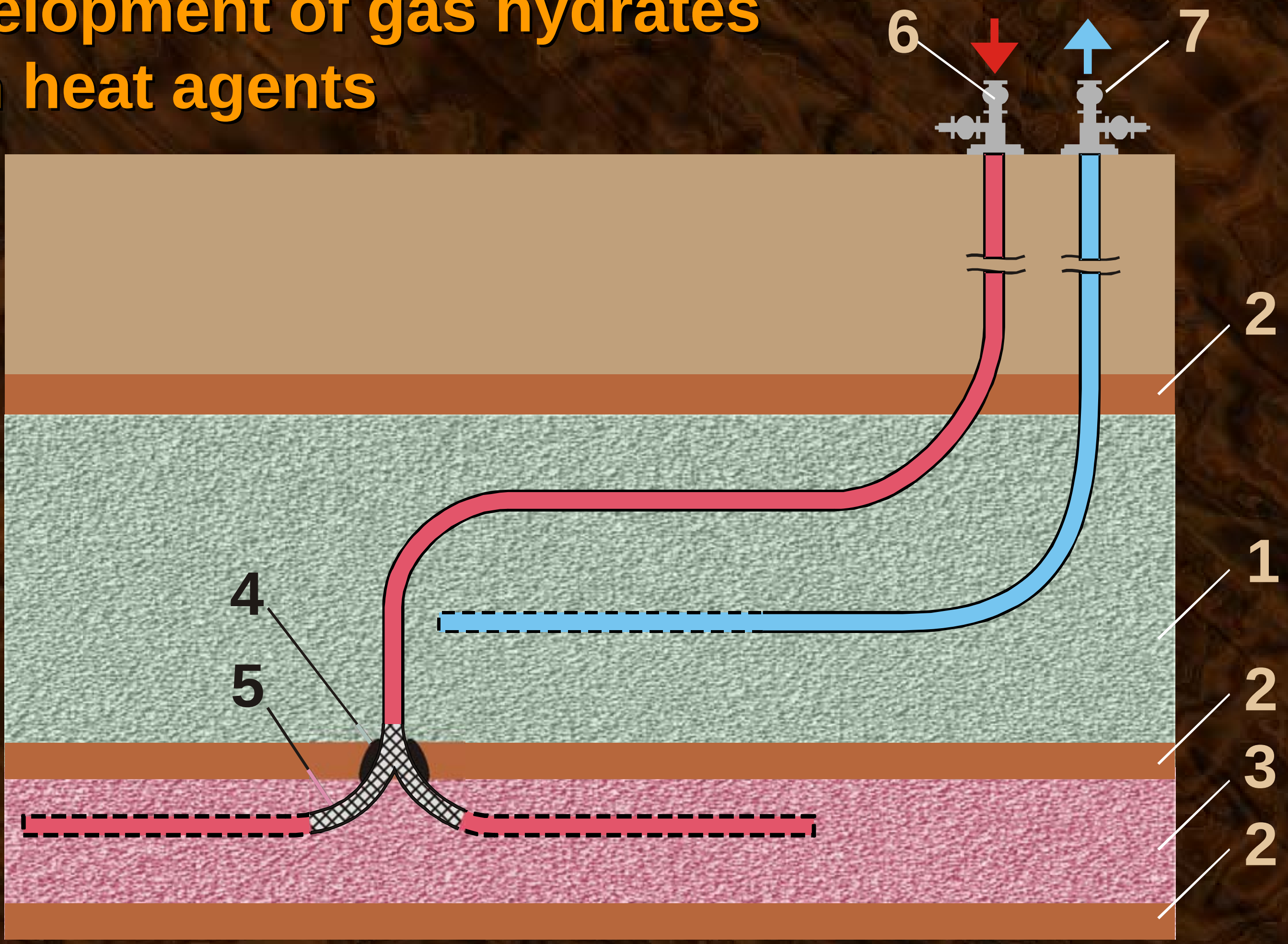
In 2001 at the Gubkin State Russian University of Oil and Gas

THERMAL METHODS

and techologies for recovering gas from hydrates were suggested by the Gas Production Department

K.S.Basniev ksb@gubkin.ru, k_basniev@mail.ru

Method of development of gas hydrates using injection heat agents



1 – gas hydrate deposit;

2 –impermeable layer;

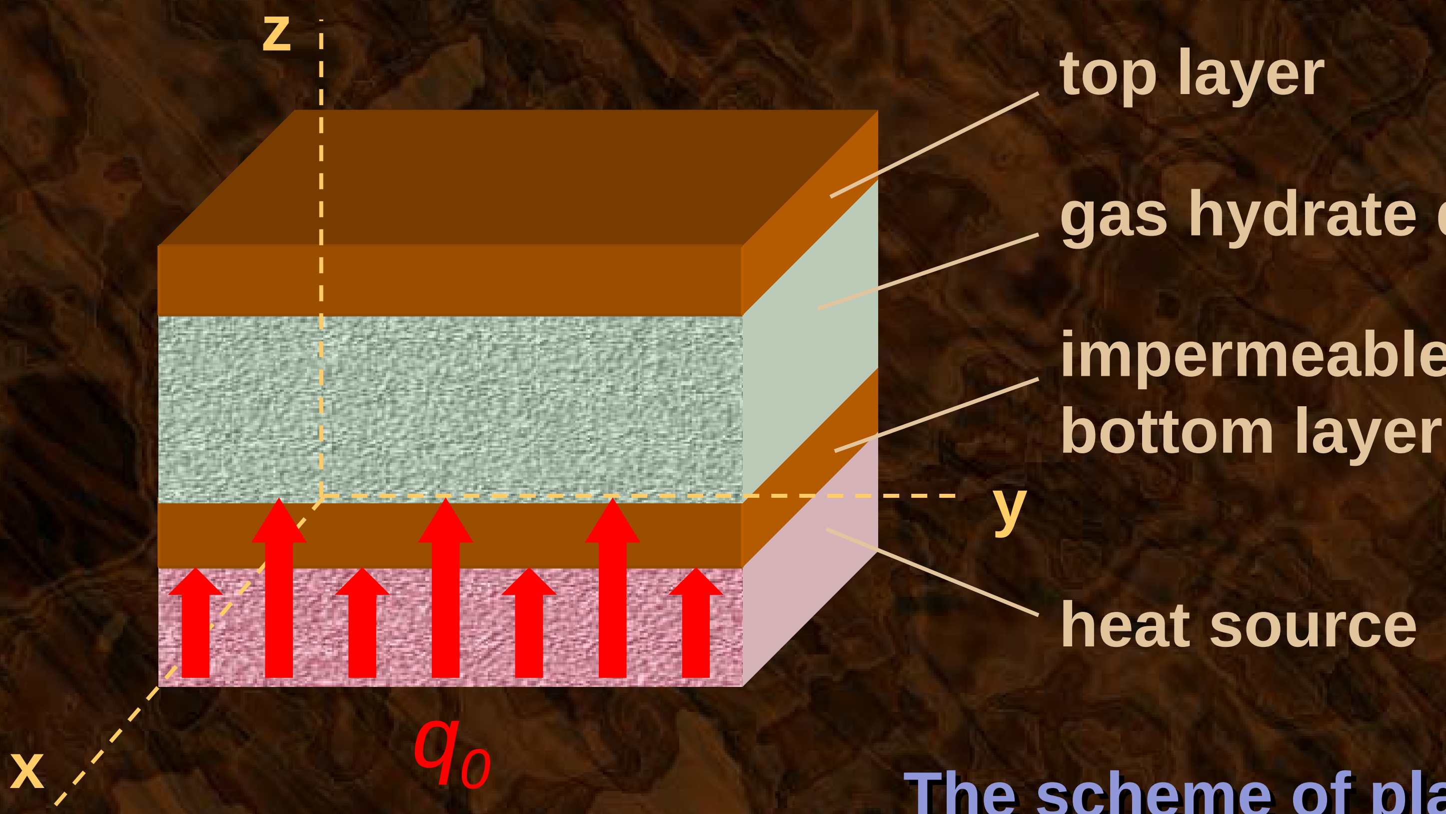
3 – liquid heat agents;

4 – packer;

5 – cement bridge; 6 – injection well; 7 – production well.

K.S.Basniev ksb@gubkin.ru, k_basniev@mail.ru

Thermodynamic Tasks Of Gas Hydrate Decomposition Under Field Conditions



The scheme of plane task of gas hydrate decomposition in a formation

K.S.Basniev ksb@gubkin.ru, k_basniev@mail.ru

Essence of the thermal method consists of injecting liquid heat agents under the impermeable bottom of formation and creating conditions for effective heat transfer for solid gas hydrate decomposition.

K.S.Basniev ksb@gubkin.ru, k_basniev@mail.ru

Task Arrangement

Conservation of gas and water:

$$m\frac{\partial}{\partial t}\{S_h(1-\varepsilon)\rho_h+(1-S_h)(1-S_w)\rho_g\}+div\,\rho_g v_g=0$$

$$m\frac{\partial}{\partial t}\{S_h\varepsilon\rho_h+(1-S_h)S_w\rho_w\}+div\,\rho_w v_w=0$$

Conservation of energy:

$$\rho c\frac{\partial T}{\partial t}+(\rho_w c_w v_w+\rho_g c_g v_g)gradT=$$
$$=-v_w gradp+m(1-S_h)(1-S_w)\frac{\partial p}{\partial t}+m\rho_h Q\frac{\partial S_h}{\partial t}+div\lambda gradT$$

Darsy’s equations for water and gas:

$$v_i=-\frac{k_i}{\mu_i}f_i(S_h,S_w)gradp$$

Equation of state:

$$p=\rho_g RT$$

Phase equlibrium equition:

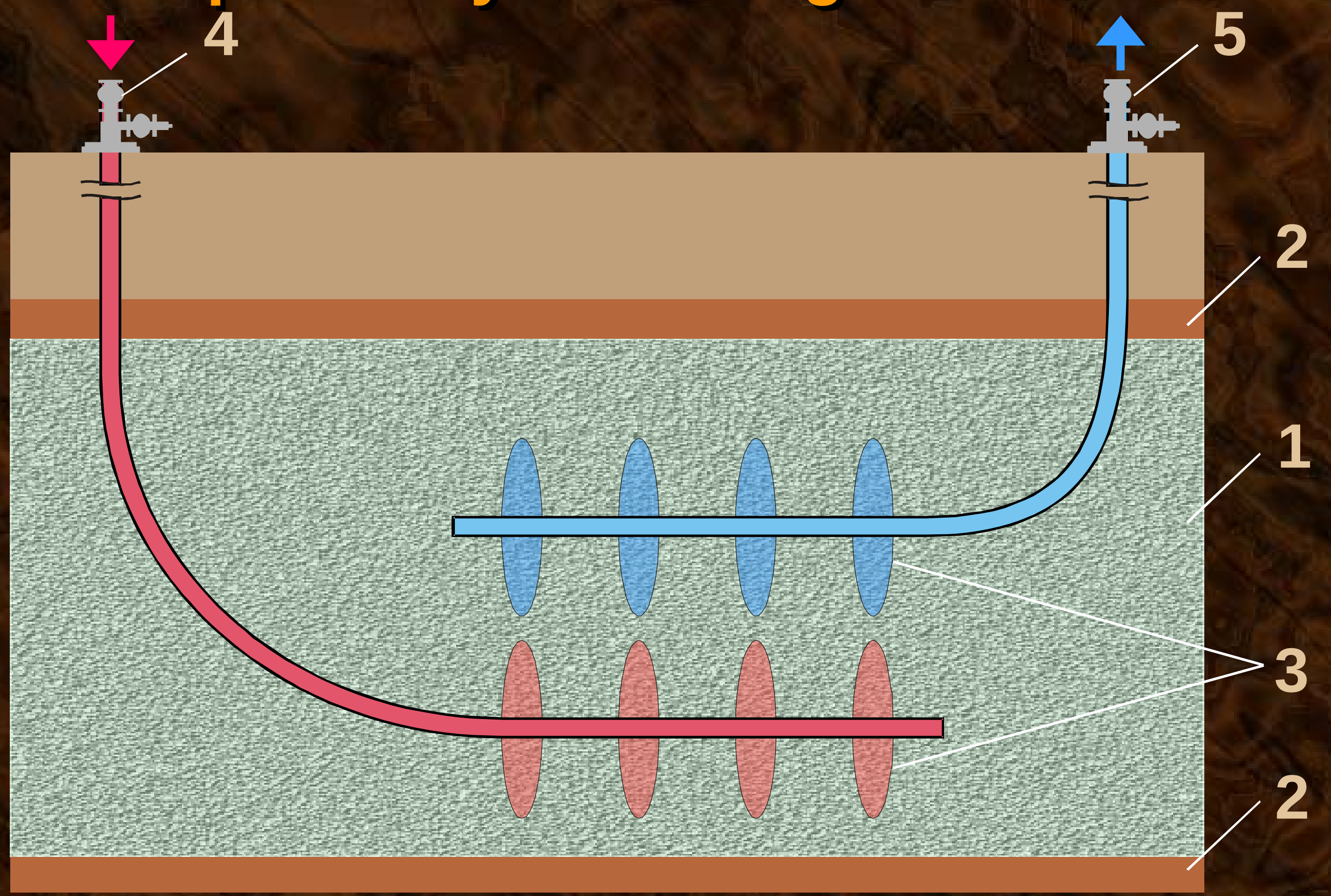
$$p(T)=p(0)\exp\frac{T-T(0)}{\alpha}$$

K.S.Basniev ksb@gubkin.ru, k_basniev@mail.ru

Heat and mass transfer can be increased by hydrofracturing. The system of horizontal wells designed for radioactive waste utilization, heated gas and hot water injection also facilitates this effect.

K.S.Basniev ksb@gubkin.ru, k_basniev@mail.ru

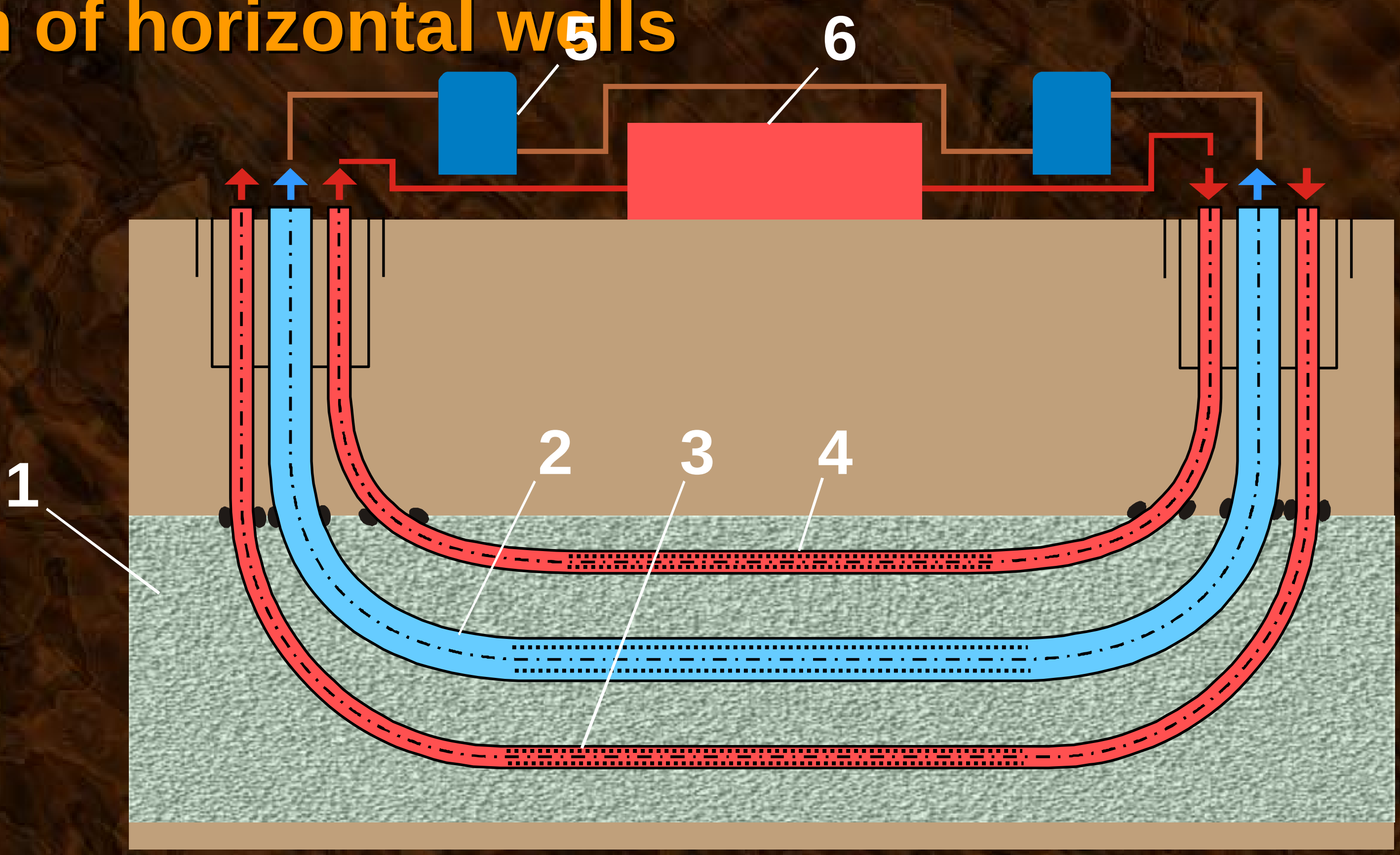
Hydrate field development by fracturing



1 – gas hydrate deposit; 2 – impermeable layer;
3 – fracture; 4 – injection well; 5 – production well.

K.S.Basniev ksb@gubkin.ru, k_basniev@mail.ru

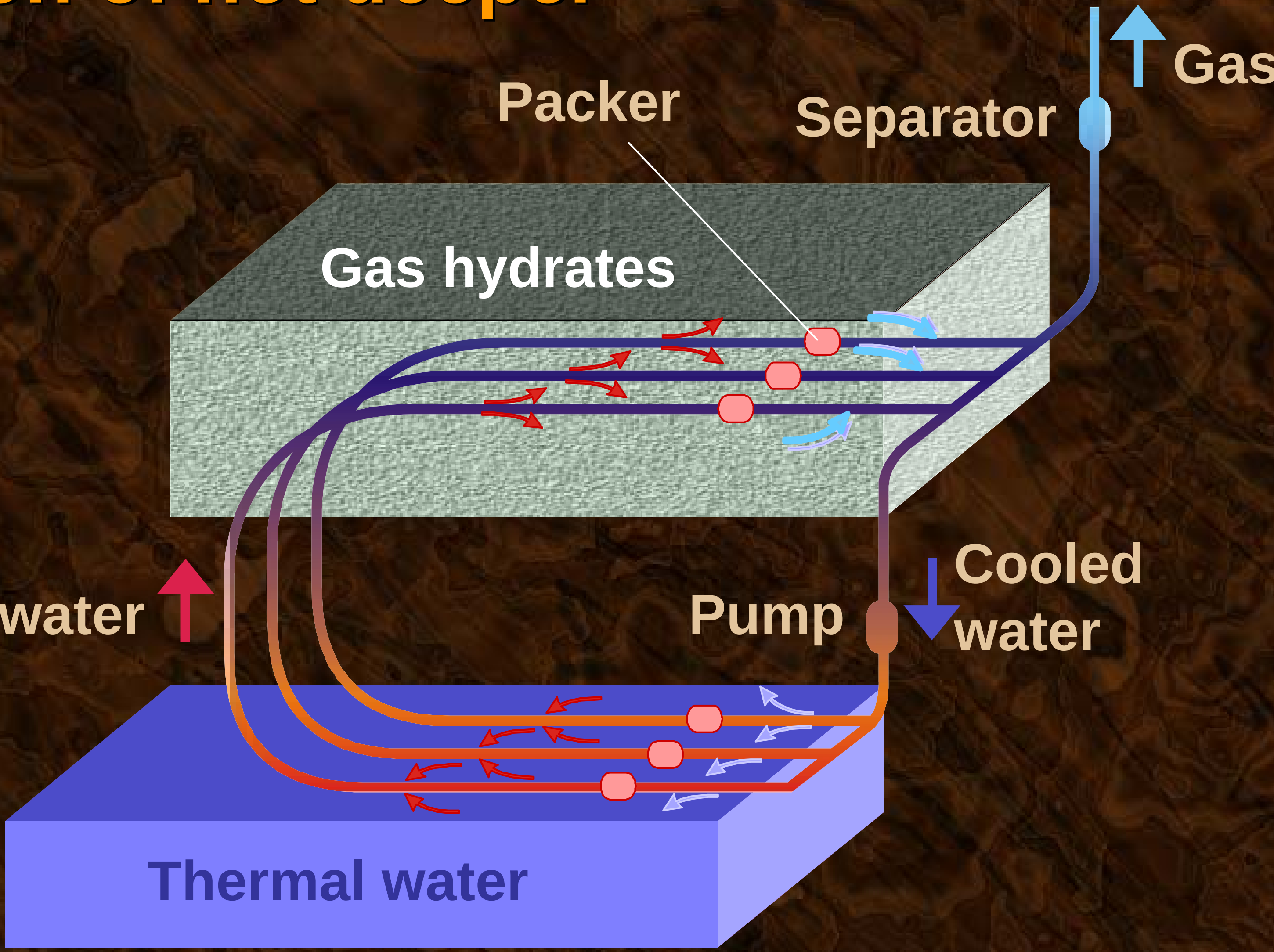
Method of hydrate field development by system of horizontal wells



1 - gas hydrate deposit; 2 - recovering trunk; 3, 4 - injecting horizontal trunks; 5 - equipment for gas recovery; 6 - equipment for injection of thermal agent

K.S.Basniev ksb@gubkin.ru, k_basniev@mail.ru

Injection of hot deeper water



K.S.Basniev ksb@gubkin.ru, k_basniev@mail.ru

The results were presented at XXII World Gas Conference (Tokyo, 2003), IGRC (Vancouver,2004), Oil and Gas International Conference (Krakow, 2004) and many conferences and symposiums in Russia. The methods suggested were patented.

K.S.Basniev ksb@gubkin.ru, k_basniev@mail.ru

Thank you
谢谢

K.S.Basniev ksb@gubkin.ru, k_basniev@mail.ru